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PATENT APPLICATION

CONNECTORIZED SILICON BENCH FOR PASSIVELY ALIGNING OPTICAL FIBERS

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Connectorized Silicon Bench for Passively Aligning Optical Fibers

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to fiber optic connectors, and more particularly, to a connectorized silicon bench and stepped ferrule that aids in the passive alignment of optical fibers and optical components on the bench.

Description of the Related Art

[0002] With the ever increasing popularity of the Internet and other data networks, fiber optics have become more and more prevalent. Since fiber has the capability of transmitting significantly more data than copper wires or wireless networks, a significant majority of the new networking infrastructure currently being implemented is based on fiber optics.

[0003] Fiber optic networks can generally be characterized as either "long" haul or "short" haul. Long haul networks are used to transmit data over long distances, such as between major metropolitan areas, across continents or oceans. Long haul networks typically rely on single mode fibers that are capable of transmitting only a single data stream of information. These cables are typically between 125 microns in diameter and have a single fiber optic inner core of approximately 8 microns. In contrast, short haul networks can are typically "multi-mode. Multi-mode cables typically have an outer diameter of approximately 125 microns and an inner fiber optic core of approximately 50 microns.

[0004] While much of the communications infrastructure being built to day is based on fiber optics, most computing environments still operate in the electrical domain. As a consequence, data signals have to be converted from the electrical to the optical domain, and vice versa, at equipment interfaces. Individual fiber cables therefore terminate at the junction at either an optical receiver, such as a photo-detector, that converts light pulses

received over the fiber into electrical signals or an optical emitter, like a laser or LED, that converted electrical signals into light pulses and transmits them down the fiber.

[0005] A connector is typically used to connect the fiber with the optical detector or emitting source (hereafter sometimes generically referred to as "optical component"). A connection is typically made by including a lens that is positioned between the optical component and the end of the fiber. During data transmission, as the light pulses exit an emitter, the light tends to diverge. The lens converges the light to focus it on the cross section of the termination point of the fiber. During data receipt, the opposite occurs. The lens focuses or converges the diverged light exiting the fiber onto the optically sensitive surface of the photo-detector.

[0006] Since data transmission takes place in the form of light pulses traveling through a thread of glass, it is important that the optical component, lens and optical fiber are all in proper alignment. Ideally, tolerances should be within a few microns. To achieve these tolerances, active alignment is needed. With active alignment, the optical component and lens are first mounted onto the substrate. The fiber is next placed on the substrate. Light is then transmitted through the fiber while a robot positions the substrate relative to the fiber. At the point where the highest intensity of light from the fiber is measured, the assembly is considered "aligned". The fiber is then locked into place on the substrate to maintain the alignment. A problem with the aforementioned package is that fiber attach results in a fiber "pigtail" which extends from the substrate. A ferrule connected to the pigtail is required to terminate the pigtail and to connect the fiber to an optical network or link. Traditional packages such as 'butterfly' packages thus require connectorization separate to the optical package itself.

[0007] Fibers can also be aligned to emitting and receiving components using a silicon optical bench which provides accurate mechanical alignment to approximately plus or minus one micron, but the assembly typically requires a package resulting in a fiber cable pigtail. A ferrule of some type is traditionally still needed to terminate the pigtail and enable connection to the main fiber link.

[0008] A ferrule that is integrated directly onto a silicon optical bench and that enables a direct optical connection interface to the silicon optical bench without the intermediate pig-tail fiber is therefore needed.

SUMMARY OF THE INVENTION

The present invention relates to a ferrulized silicon bench that aids in the connectorization of optical fiber cables to optical components on the bench. The apparatus includes a bench having an optical component, a groove formed in the bench, the groove configured to accommodate an optical fiber; and a ferrule, including a recess region to accommodate the optic fiber when the ferrule is mounted onto the bench. The groove and the ferrule cooperate to mechanically align the optical fiber and the optical component on the bench. A connector sleeve, which accommodates the silicon bench and ferrule, includes a receptacle that is configured to receive a plug-in connector which optically couples the optical fiber to an optical network or link.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a perspective view of a silicon bench according to the present invention;

Figure 2 is a perspective view of a stepped ferrule used with the silicon bench of the present invention;

Figure 3 is a side cross-section view of the stepped ferrule used with the silicon bench of the present invention;

Figure 4 is a perspective view of the stepped ferrule with the silicon bench of the present invention;

Figure 5 is a cross section view of the stepped ferrule in passive alignment with the silicon bench; and

Figure 6 is a side cross section view of a connector sleeve used to connectorize the silicon bench according to one embodiment of the present invention

Figures 7A –7B illustrate another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] In the following description, numerous specific details are set forth to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some or all of these specific details. In other instances, well known process steps have not been described in detail in order to avoid unnecessarily obscuring the present invention.

[0010] Referring to Figure 1, a perspective view of a silicon bench according to the present invention is shown. The silicon bench 10 includes a pad 12 for mounting an optical component 14 (either an emitter, photo-detector, or both), a recess region 16 for recessing a lens or waveguide 18, and an alignment V-groove 20 with angled side walls 22. The recess region 16 and the V-groove 20 are etched into the silicon bench 10. Using well known semiconductor processing techniques, extremely high tolerance levels may be obtained, for example one micron or less.

[0011] Referring to Figure 2, a perspective view of a stepped ferrule 30 used with the silicon bench 10 is shown. The stepped ferrule 30 is substantially cylinder in shape and includes a stepped region 32 and a recess region 34 extending the length of the ferrule 30 for receiving a fiber optic cable (not shown). In one embodiment, the ferrule 30 is made from a precision machined piece of ceramic. In other embodiments, the ferrule can be made from other materials such as plastic, metal or any other suitable material.

[0012] Referring to Figure 3, a side cross-section view of the stepped ferrule 30 is shown. As clearly illustrated in this figure, the recess region 34 runs the length of the ferrule and is used to accommodate a fiber optic cable 36 when inserted through the ferrule. According to various embodiments, the length of the stepped region compared to relative overall size of the ferrule 30 may vary.

[0013] Referring Figure 4, a perspective view of the stepped ferrule mounted onto the silicon bench 10 of the present invention is shown. As is illustrated in the figure, the fiber optic cable 36 is inserted through the recess region 34 of the ferrule 30. The ferrule 30 is then mounted onto the bench 10 such that the fiber optic cable 36 adjacent the stepped region 32 fits into the V-groove 20 of the silicon bench 10. The angled side walls 22 engage the fiber optic cable 36, causing the cable 36 to be self

aligned with the lens or waveguide 18 and the optical component 14 on the silicon bench 10.

[0014] Figure 5 is a cross section view of the fiber optic cable 36 and the stepped ferrule 30 shown in passive alignment with the silicon bench 10. As is evident in this figure, the sloped or angled side walls 22 of the V-groove 20 aid in the passive alignment of the fiber optic cable 36 with the silicon bench 10. Specifically, the tolerances at which the side walls 22 of the V-groove 20 are formed assures that the cable 36 is aligned within a very high degree of accuracy with respect to the optical component 14 and lens 18 on the bench 10. As a result, there is no need to perform active alignment of the fiber optic cable 36 and the optical component 14 and lens or waveguide 18 using a robot or the like to position the bench 10 and the fiber optic cable 36.

[0015] Referring to Figure 6, a side cross section view of the stepped ferrule aligned with the silicon bench and a plug in connector according to one embodiment of the present invention is shown. The connector 50 includes a sleeve 52 that fits over the silicon bench 10 and ferrule 30. The sleeve 50 includes a receptacle 54 which is configured to receive a plug-in connector 56.

[0016] Referring to Figure 7A-7C, another embodiment of the present invention as shown. Figure 7A shows a silicon bench 70 which includes a plurality of pads 12 for mounting an optical components 14 (either an emitter or photo-detector), a plurality of recess regions 16 for recessing a plurality of lenses or waveguides 18, and a plurality of alignment V-grooves 20, each with angled side walls 22. The recess region 16 and the V-groove 20 are etched into the silicon bench 10. Figure 7B shows a stepped ferrule 80 with multiple recess regions 82. The ferrule 80 is intended to be used with the silicon bench 70. Figure 7C shows the ferrule 80 mounted onto the silicon bench 70. With this embodiment, multiple optical fibers 36 can be passively aligned with the optical components 14 on the silicon bench 70 as described above.

[0017] Although illustrative embodiments and applications of this invention are shown and described herein, many variations and modifications are possible which remain within the concept, scope, and spirit of the invention, and these variations would become clear to those of ordinary skill in the art. For example, the alignment groove can be either V-shaped as described above or trench shaped. Accordingly, the present embodiments are to be considered as illustrative and not restrictive, and the

invention is not to be limited to the details given herein, but may be modified within the scope and equivalents of the appended claims.